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(12) # EUROPEAN PATENT APPLICATION

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(54) **Device for processing optical information and method of manufacturing a coma correction plate as used in such a device.**

(57) A device for processing optical information is provided comprising a system of optical elements (6, 7, 9, 10, 12, 13) arranged along an optical main axis (11) for guiding a light beam (4) to a radiation-sensitive detection system (8), in which at least one coma correction plate (13, 20, 21) is provided comprising a substrate having a dielectric layer varying in thickness such that the differences in path length in the light beam which are formed by coma in the system of optical elements are at least partly compensated for.

A method of manufacturing such a coma correction plate is provided in which, during vapour deposition of the dielectric layer in a vapour deposition device, a plate-shaped substrate (32) is moved at a constant speed below a template (33) parallel to an axis (34) which is situated in the plane of the template, which template (33) is situated between the vapour deposition source (30) and the substrate (32) and has an aperture (35), which aperture lies across axis (34) and has an edge (36) whose profile on either side of the axis varies as a third power function of the distance to the axis, the point of intersection (37) of the axis with the part of this edge being taken as zero point.

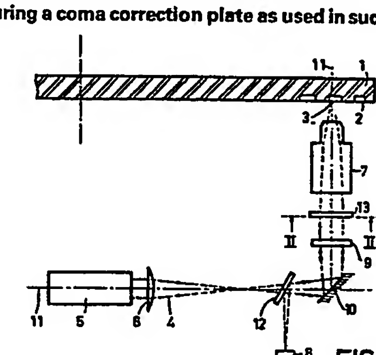

FIG.1

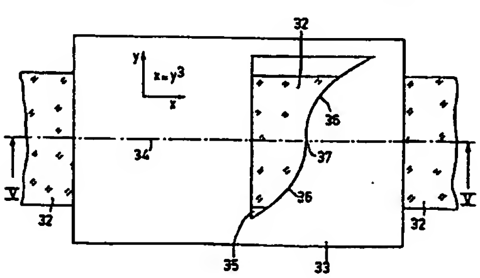

FIG.6

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Croydon Printing Company Ltd.

"Device for processing optical information and method of manufacturing a coma correction plate as used in such a device"

The invention relates to a device for processing optical information, comprising a system of optical elements arranged along an optical main axis for guiding a light beam to a radiation-sensitive detection system.

The invention also relates to a method of manufacturing a coma correction plate as used in said device.

A device according to the invention may be, for example, an objective of a television camera, a microscope or a device for reading a record carrier, on which information is recorded in an optically readable information structure.

Such a device as mentioned in the opening paragraph is disclosed in Philips' Technisch Tijdschrift, 33, No. 7, pp. 194-197, which describes a device for reading a record carrier. In this case it is a VLP disc player (VLP is a trade mark of N.V. Philips' Gloeilampenfabrieken) which is meant to read video and/or audio information which is recorded on a disc. The information is recorded on the surface of the disc in the form of pits which are 0.8 μm wide and approximately 0.16 μm deep and which have a variable length. The pits are situated on a spiral-like track having a pitch of approximately 2 μm. For reading the information, a light spot is projected on the track by means of a light source and a number of optical elements. The light is reflected at the disc surface and captured again by the optical elements and concentrated on a detector, for example a photodiode. Deflection occurs at the pits in the disc surface and the deflected radiation no longer falls mainly on the optical elements. So when the detector passes the pits it will receive less light than when it passes a

flat part. In this manner the signal of the detector is modulated. The information may be coded in the frequency of the pits and/or in the ratio of the length of the pits relative to the length of the intermediate region present between two pits. The information may also be coded in a digital form. In addition to video and audio information, digital information, for example from and for a computer, may also be recorded on the disc.

An optical system which can observe the pits individually and which can follow the track so accurately that cross-talk between two adjacent tracks is prevented must satisfy very high requirements of display sharpness and mechanical precision. On the other hand, with a view to production in large numbers, the system must be as simple as possible, cheap and easy to adjust.

In cheap systems consisting of optical elements, no narrow centring tolerances can be imposed so that inadmissible axial coma may occur. In the above-described VLP-players this coma is expressed, for example, in a one-sided haze (comet-tail) near the light spot.

It is therefore an object of the invention to provide a device of the kind described in the opening paragraph which, due to a simple and cheap measure, has a small coma and which is easy to adjust.

According to the invention, a device of the kind described in the opening paragraph is characterized in that the system of optical elements comprises at least one coma correction plate comprising a substrate having a dielectric layer varying in thickness such that the differences in path length in the light beam which are formed by coma in the system of optical elements are at least partly compensated for.

The thickness of the dielectric layer represents the correction of path length. The refractive index of the material of the dielectric layer influences the velocity of light in the layer and hence the differences in path length.

Such coma correction plates can also be used very readily in devices in which the optical components have large dimensions.

The dielectric layer may be provided, for example, by means of a spraying process, by sputtering or by vapour deposition. When the differences in thickness variation are small, vapour deposition is of course the best suitable method. As substrate materials, plates of, for example, glass or quartz may be used. However, it is alternatively possible to use another optical element, for example a lens, a mirror or a filter, as a substrate. The dielectric layer may be manufactured, for example, from SiO_2, ZnS, TiO_2, etc..

In the device according to the invention the dielectric layer is preferably manufactured from a material which has a refractive index which is equal to or substantially equal to the refractive index of the material of the substrate. In that case substantially no reflections occur at the interface between the dielectric layer and the substrate, which reflections may cause interferences. In a VLP-player, for example, these reflections may give rise to undesired fluctuations in the output power of the laser. Reflected light at the area of the detector may also interfere with the primary modulated light beam and give rise to very deep modulation of the detector signal.

Such fluctuations of the output power and modulation are undesired in many cases and also in other applications, for example, interferometers.

A preferred embodiment of the device in accordance with the invention is characterized in that two coma-correction plates are used and the thickness Z of the dielectric layers on the plates as a function of distance from the optical main axis in a first direction is constant and in the direction η perpendicular thereto varies according to the function

$$Z = a\eta^3$$

where $\eta = 0$ is situated on the optical main axis and wherein a is a constant which depends on the desired quantity of compensating coma W_{31} and on the refractive index n of the material of the dielectric layer, and is given by:

$$a = \frac{4}{3\sqrt{3}} \cdot \frac{W_{31}}{(n-1)}$$

and which first directions of the coma correction plates are rotated around the said optical main axis by an angle of 60° relative to each other.

The thickness variation of the dielectric layer on the first coma correction plate is

$$Z_1 = a\eta_1^{\ 3}$$

and on the second coma correction plate

$$Z_2 = a\eta_2^{\ 3}$$

When changing to polar coordinates we find for the resulting thickness of the two layers that:

$$Z = Z_1 + Z_2 = a\,(\eta_1^{\ 3} + \eta_2^{\ 3}) =$$

$$= a\,r^3.\left\{\sin^3(\varphi - 30^\circ) + \sin^3(\varphi + 30^\circ)\right\}$$

$$= \tfrac{3}{4}\,a\sqrt{3}\,r^3\sin\varphi$$

which is exactly the thickness variation required for correcting a given coma. The layers with the thickness variation Z_1 and Z_2 may be provided one each on either side of a single substrate so that two integrated coma correction plates are formed. However, it is alternatively possible in accordance with the invention that one coma correction plate is used and the thickness Z of the dielectric layer as a function of position in polar coordinates r and φ on the plate varies mainly according to the function:

$$Z = \tfrac{3}{4}\,a\sqrt{3}\,r^3\sin\varphi$$

wherein $\underline{r} = 0$ is situated on the optical main axis and wherein $\underline{a}$ is a constant which depends on the desired quantity of compensating coma W_{31} and on the refractive index $\underline{n}$ of the material of the dielectric layer, and is given by:

$$a = \frac{4}{3\sqrt{3}} \cdot \frac{W_{31}}{(n-1)}$$

W_{31} determines the values of the coma term in a function $W_{(r,\varphi)}$ which represents the wave front aberrations. This is a generally known notation for the aberrations and is used, for example, in J. Opt. Soc. Am. 69, No. 1, 14, 1979 (formula 6.27) and in "wave theory of aberrations" of HH. Hopkins, Oxford, Clarendon Press 1950.

The invention will now be described in greater detail, by way of example, with reference to the drawings, in which:

Figure 1 shows diagrammatically a device according to the invention,

Figure 2 shows diagrammatically a coma correction plate,

Figures 3a, b and c are a diagrammatic sectional view and plan views of two coma correction plates.

Figure 4 shows diagrammatically an integrated coma correction plate, and

Figures 5 and 6 further explain the method of manufacturing coma correction plates.

Figure 1 shows diagrammatically a device according to the invention, in this case a device for reading a record carrier on which information, for example, video and/or audio information, has been provided in an optically readable information structure. In this Figure a disc-shaped record carrier 1 which comprises information tracks 2 is shown in cross-section. A light spot 3 is incident on the record carrier, which spot is formed by a light beam 4 originating from a light source 5

in which beam a lens 6 is placed. The light beam 4 is focused by an objective 7 on the plane of the information tracks to form the light spot 3 which has a diameter in the order of magnitude of the pits in the information tracks. The light beam is modulated and reflected by the information structure and traverses the objective 7 for the second time and is incident on the detector 8. The light from the light source 5 is linearly polarized. As a result of this, separation of the incident and reflected light can be obtained by means of a 1/4 λ plate 9 and a polarization-sensitive dividing mirror 12. The system furthermore comprises a flat mirror 10. Since the elements of the objective 7 are not accurately centred around the optical main axis 11, a coma correction plate 13 is provided which has a coma which at least partly compensates for the coma of the objective 7. As a result of this a light spot without a one-sided haze (comet-tail) is obtained.

Figure 2 is a diagrammatic elevation of the coma correction plate 13. The optical main axis is perpendicular to the plane of the drawing and passes through the point r = 0. The plate consists of a substrate of quartz having a refractive index $n = 1.46$ with thereon a dielectric layer of SiO_2 varying in thickness according to the invention. The thickness Z of the dielectric layer depends <u>inter alia</u> on the place P on the plate defined by the polar coordinates r and φ. In practice, an assortment of coma correction plates of different strengths is manufactured. For example, a plate having a thickness variation from 0 to 2000 Å, a plate having a thickness variation from 0 to 4000 Å and a plate having a thickness variation from 0 to 6000 Å, for use in a device shown in Figure 1, in which a He-Ne laser is used as a light source. Dependent on the coma observed in a system, a coma correction plate having a given strength is selected from said assortment, placed in the device and rotated about the optical main

axis until the total coma is minimum and the device satisfies the required specifications. The manufacture of coma correction plates will be described in the specification with reference to Figures 5 and 6.

Figure 3a is a sectional view of a set of two coma correction plates 20 and 21 parallel to the X-Y plane perpendicular to the optical main axis 11. The X-axis is perpendicular to the plane of the drawing. Figures 3b and 3c are elevations of the two plates. The optical main axis 11 in both Figures is perpendicular to the plane of the drawing and passes through the point O ($\eta = 0$, $\xi = 0$). The thickness Z of the dielectric layer on the plate 20 is constant in the ξ_1 direction and varies in the η_1 direction according to the function:

$$Z = a\eta_1^3$$

The thickness Z of the dielectric layer on plate 21 is constant in the ξ_2 direction and varies in the η_2 direction according to the function:

$$Z = a\eta_2^3$$

The η_1 and η_2 directions make an angle of 60° with each other. This has for its result, as already proved above, that the resulting thickness of both dielectric layers together varies according to:

$$Z = \frac{3}{4} \cdot a \cdot \sqrt{3}\, r^3 \sin \varphi$$

when changing to polar coordinates r and φ.

In Figure 4 the dielectric layers according to Figures 3b and 3c are provided on the two sides of one substrate 22.

A method of manufacturing coma correction plates will now be described in greater detail, by way of example, with reference to Figures 5 and 6.

Figure 5 shows diagrammatically a vapour deposition device comprising a vapour source 30 for evaporating the dielectric material to form the dielectric

layer 31 on the strip-shaped substrate 32. During the vapour deposition the substrate 32 is passed below a template 33 at a constant speed V parallel to axis 34. The template 33 comprises an aperture 35. Figure 6 shows the shape of said aperture 35. Aperture 35 lies across axis 34. An edge 36 of the aperture has a profile on either side of the axis which varies as a third power function of the distance to the axis 34, the point of intersection 37 of the axis 34 with that part of the edge 36 being taken as zero point. The curvature of the edge 36 of the edge varies according to

$$x = \underline{c}\, y^3,$$

where $\underline{y}$ is positive on one side of the zero point 37 and is negative on the other side. The desired thickness variation can be obtained by choice of the constant $\underline{c}$ and/or the velocity V. By this way of vapour deposition, a strip-shaped substrate is obtained having a thickness variation of the dielectric layer which is constant in the direction of the axis 34 and has the desired third power variation in the direction perpendicular thereto. This strip-shaped substrate covered in this manner can then be divided into small substrates which may be used in a system of two coma correction plates as described in the Figures 3<u>a</u>, <u>b</u> and <u>c</u>. However, it is alternatively possible to rotate the small substrates covered with one dielectric layer in the plane of the substrates over an angle of 60° and again cover them in the vapour deposition device yielding a coma correction plate as described in Figure 2.

CLAIMS

1. A device for processing optical information, comprising a system of optical elements (6, 7, 9, 10, 12, 13) arranged along an optical main axis (11) for guiding a light beam (4) to a radiation-sensitive detection system (8), characterized in that at least one coma correction plate (13, 20, 21) is provided in the system of optical elements comprising a substrate having a dielectric layer which varies in thickness such that the differences in path length in the light beam which are formed by coma in the system of optical elements are at least partly compensated for.

2. A device as claimed in Claim 1, characterized in that the dielectric layer is manufactured from a material having a refractive index which is equal to or substantially equal to the refractive index of the material of the substrate.

3. A device as claimed in Claim 1 or 2, characterized in that two coma correction plates (20, 21) are used and the thickness Z of the dielectric layers on the plates from the optical main axis (11) in a first direction is constant and in the direction η perpendicularly thereto varies according to the function:

$$Z = a\eta^3$$

wherein $\eta = 0$ is situated on the optical main axis and wherein a is a constant which depends on a desired quantity of compensating coma W_{31} and on the refractive index n of the material of the dielectric layer, and is given by:

$$a = \frac{4}{3\sqrt{3}} \cdot \frac{W_{31}}{(n-1)}$$

and which first directions of the coma correction plates

are rotated around the said optical main axis over an angle of 60^{o} relative to each other.

4. A device as claimed in Claim 3, characterized in that two integrated coma correction plates are used in which the dielectric layers are provided on the two sides of one substrate (22).

5. A device as claimed in Claim 1 or 2, characterized in that one coma correction plate (13) is used and the thickness Z of the dielectric layer as a function of position in polar coordinates r and φ on the plate varies mainly according to the function

$$Z = \frac{3}{4} \cdot a \sqrt{3}\, r^3 \sin \varphi$$

wherein r = 0 is situated on the optical main axis (11) and wherein a is a constant which depends on a desired quantity of compensating coma W_{31} and on the refractive index n of the material of the dielectric layer, and is given by:

$$a = \frac{4}{3\sqrt{3}} \cdot \frac{W_{31}}{(n-1)} .$$

6. A device as claimed in any of the preceding Claims, characterized in that the substrate is an optical element, for example a filter, a mirror, a $1/4\lambda$ -plate or a lens.

7. A device as claimed in any of the preceding Claims, characterized in that it is a device for reading a record carrier (1) on which information, for example video and/or audio information, is provided in an optically readable information structure (2), which device comprises a source of radiation (5) for generating the light beam (4).

8. A method of manufacturing a coma correction plate as used in a device as claimed in Claim 3, characterized in that during vapour deposition of the dielectric layer layer in a vapour deposition device a plate-shaped substrate (31) is moved at a constant speed below a template (33) parallel to an axis (34) which is situated

in the plane of the template, which template (33) is situated between a vapour deposition source (30) and the substrate (31) and has an aperture (34), which aperture lies across the axis and has an edge (36) whose profile on either side of the axis varies as a third power function of the distance to the axis, the point of intersection (37) of the axis with the part of the edge being taken as zero point.

9. A method of manufacturing a coma correction plate used in a device as claimed in Claim 4, characterized in that the method as claimed in Claim 8 is used after which the substrate provided with a dielectric layer on one side is inverted and is rotated over an angle of 60° in the plane of the substrate, after which the method as claimed in Claim 8 is used again to provide the second dielectric layer.

10. A method of manufacturing a coma correction plate as used in a device as claimed in Claim 5, characterized in that the method as claimed in Claim 8 is used, after which the substrate covered with a first dielectric layer is rotated over an angle of 60° in the plane of the substrate and the method as claimed in Claim 8 is then used again.

11. A method as claimed in Claim 10, characterized in that a strip-shaped substrate is covered with the first dielectric layer, after which said strip-shaped substrate is divided into small substrates covered with the first dielectric layer which are then rotated over 60° in the plane of the substrates and are then covered again with a second dielectric layer.

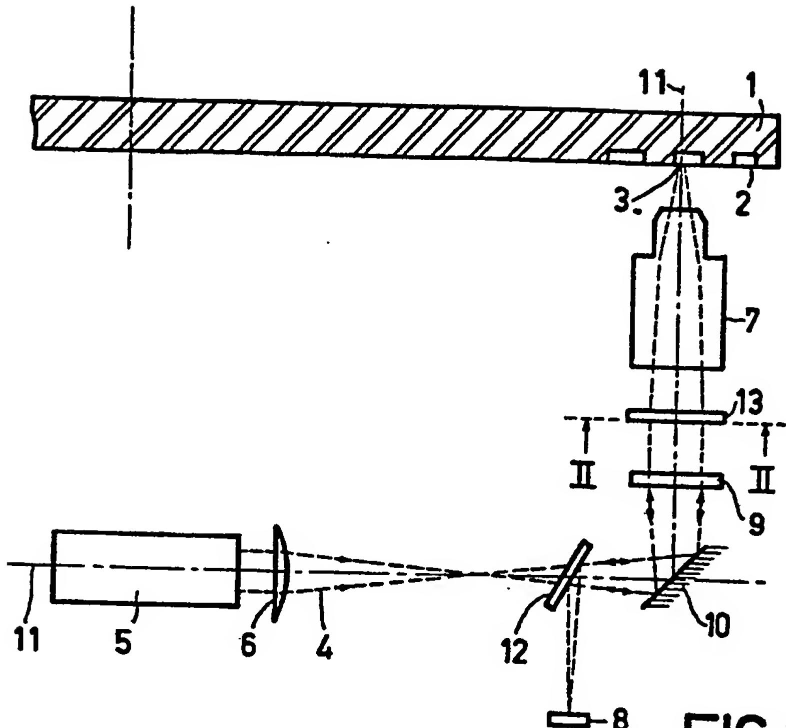

FIG.1

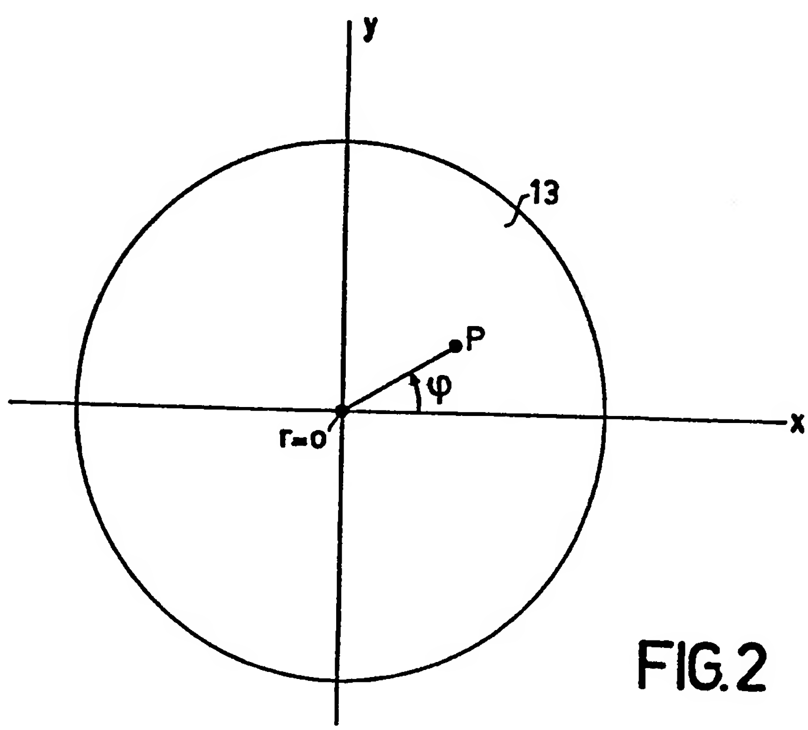

FIG.2

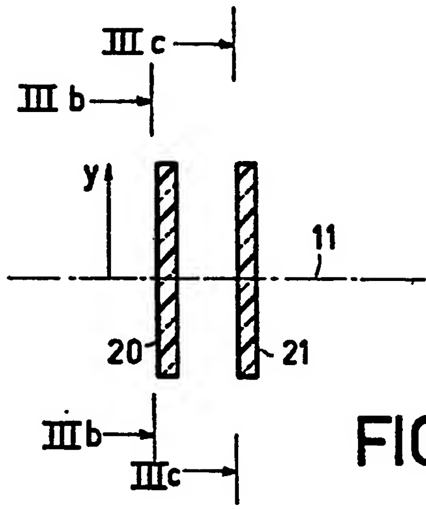

FIG.3a

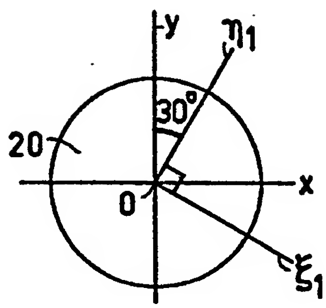

FIG.3b

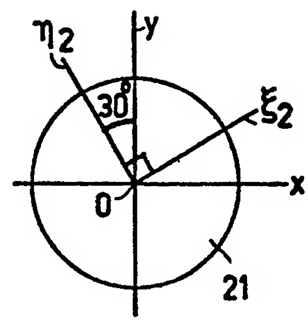

FIG.3c

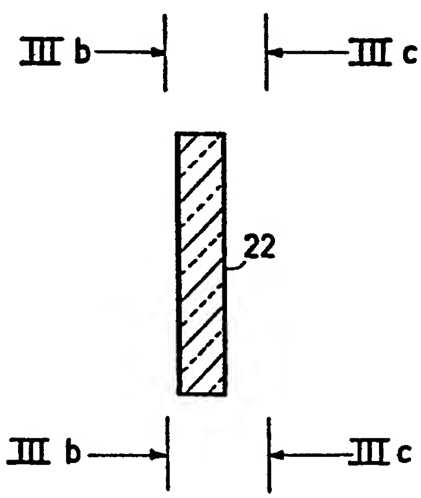

FIG.4

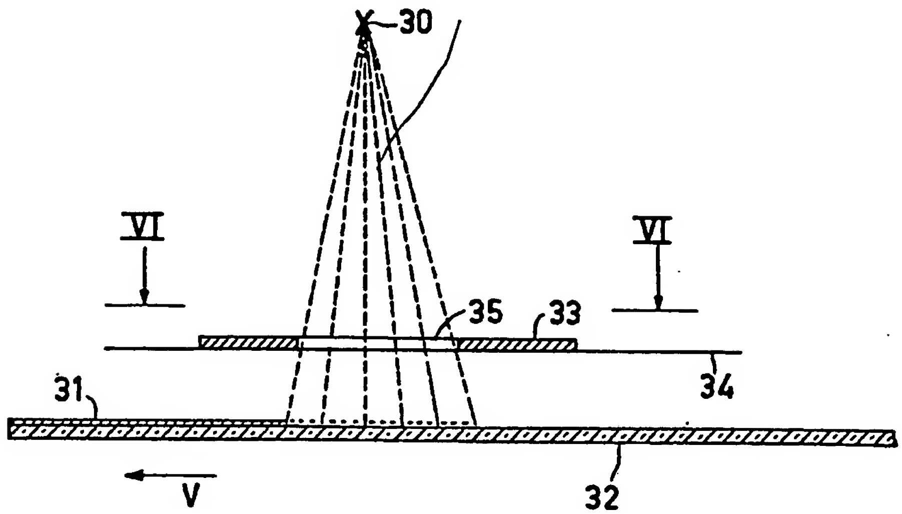

FIG.5

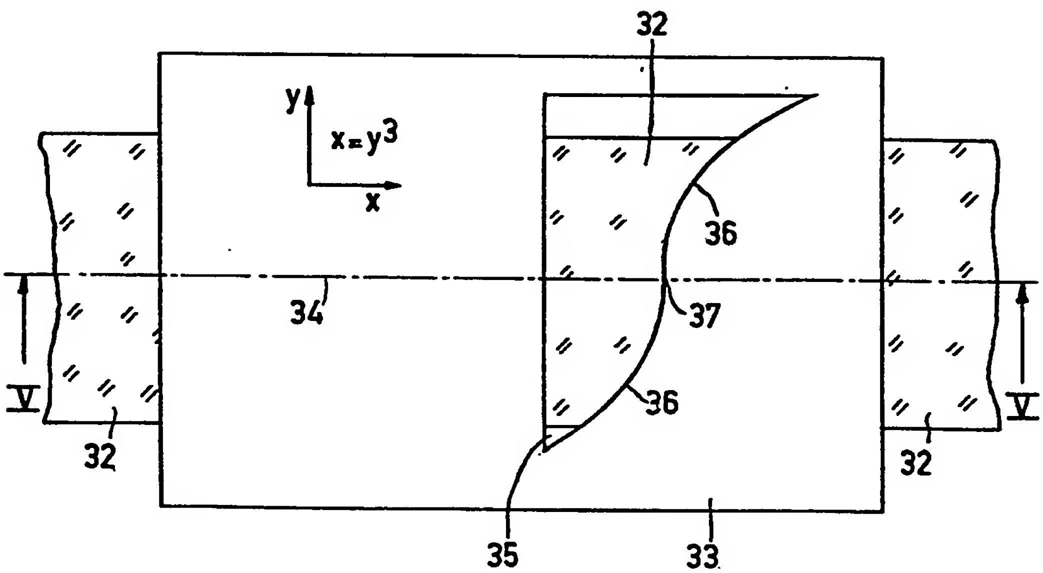

FIG.6

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EUROPEAN SEARCH REPORT

Application number
EP 81 20 0841

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	US - A - 3 097 255 (J.P. FARQUHAR and F.F. CRANDELL) * Column 1,lines 10-48, 54-58; column 2, line 28 - column 3, line 2; column 16, lines 3-75; figures 1,14,15,16 * --	1,6
	US - A - 3 558 208 (RCA CORPORATION) * Column 1, line 60 - column 2, line 21; column 5, line 58 - column 6, line 23; figures 4,5 * --	1,6,7
	APPLIED PHYSICS LETTERS, vol. 34, no. 12, June 15,1979 New York, US P.M. ASBECK et al.: "High-density optical recording with (Ga, Al)As DH lasers", pages 835-837 * Page 836, left-hand column, lines 5-33; figure 1c * --	1,6,7
	US - A - 4 215 914 (CARL ZEISS-STIFTUNG) * Column 1, lines 6-29; column 1, line 52 - column 2, line 19 * --	1,6
	DE - A - 1 497 546 (PERKIN-ELMER CORP.) * Page 1, line 1 - page 4, line 13; page 5, line 5 - page 7, line 3; figures 1,4 * & US - A - 3 476 463 -- ./.	1,4

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

G 11 B 7/08
G 02 B 27/00

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

G 02 B 27/00
27/18
G 11 B 7/08
7/12

CATEGORY OF CITED DOCUMENTS

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X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	01-12-1981	HORAK

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EUROPEAN SEARCH REPORT

Application number

EP 81 20 0841

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DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.³)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	US - A - 4 025 949 (ZEMITH RADIO CORPORATION) * Column 2, lines 10-53 * ----	1,7	
			TECHNICAL FIELDS SEARCHED (Int. Cl.³)